

WHAT IS CLAIMED IS:

1. A piezoelectric resonator comprising:

a substrate;

a vibration unit disposed on the substrate and having a structure in which at least one pair of an upper electrode and a lower electrode are opposed to each other, the upper and lower electrodes sandwiching the upper and lower surfaces of an internal thin-film portion including at least one layer of a piezoelectric thin-film; and

an external thin-film portion provided under the lower electrode and including at least one layer of one of a piezoelectric thin-film and a dielectric thin-film; wherein

the vibration unit is vibrated in an n-th harmonic, where n is an integer of 2 or greater, the upper electrode and the lower electrode are located substantially in the positions of the loops of the n-th harmonic.

2. A piezoelectric resonator according to claim 1, wherein the n-th harmonic is a second order harmonic, and the film thickness ratio $r = t_o/t_i$ in which t_o represents the thickness of the external thin-film, and t_i represents the thickness of the internal thin-film is set at a value at which the resonance frequency temperature coefficient of the entire piezoelectric resonator is nearly zero.

3. A piezoelectric resonator according to claim 1, wherein the respective thin-films of at least one of the internal thin-film portion and the external thin-film portion are combined in such a manner as to have different resonance frequency temperature coefficients.

4. A piezoelectric resonator according to claim 1, wherein the external thin-film portion includes at least one of a thin-film having an SiO_2 thin-film as a major component, a thin-film including an SiN thin-film as a major component, and a thin-film including an Al_2O_3 thin-film as a major component.

5. A piezoelectric resonator according to claim 1, wherein the internal thin-film portion includes a thin-film having ZnO as a major component, a thin-film including AlN as a major component, a thin-film including lead titanate zirconate as a major component, a thin-film including lead titanate as a major component, and a thin-film including barium titanate as a major component.

6. A piezoelectric resonator according to claim 1, wherein the substrate has one of a hole and a concavity, and the vibration unit is disposed above the one of the hole and

the concavity.

7. A piezoelectric resonator according to claim 1, wherein the piezoelectric resonator is a thickness-longitudinal vibration type resonator.

8. A piezoelectric resonator according to claim 1, wherein the substrate has a hole that passes through a top surface to a bottom surface of the substrate and the vibration unit is disposed above the hole.

9. A piezoelectric resonator according to claim 8, further comprising a diaphragm that is arranged to cover the hole.

10. A piezoelectric resonator according to claim 1, wherein the opposed electrodes are made of aluminum and the internal thin-film portion is made of zinc oxide.

11. A piezoelectric resonator according to claim 1, wherein the n-th harmonic is a second order harmonic and nodes of the second harmonic exist in the internal and external thin-film portions.

12. A piezoelectric resonator according to claim 11,

wherein the film thickness ratio $r = t_o/t_i$ in which t_o represents the thickness of the external thin-film, and t_i represents the thickness of the internal thin-film is set at a value at which the resonance frequency temperature coefficient of the entire piezoelectric resonator is nearly zero.

13. A piezoelectric resonator according to claim 12, wherein the film-thickness ratio r is preferably in the range of about 0.6 to about 1.3.

14. A piezoelectric resonator according to claim 1, wherein the resonance frequency temperature coefficient TCF is about +10 ppm/°C to about -10 ppm/°C.

15. A piezoelectric resonator according to claim 1, wherein the external thin-film portion includes two layers having different resonance frequency temperature coefficients.

16. A filter including a plurality of the piezoelectric resonators according to claim 1 and a filter circuit, wherein the electrodes of the piezoelectric resonators are connected to the filter circuit.

17. A filter including a plurality of the piezoelectric resonators according to claim 1, wherein the piezoelectric resonators are connected in a ladder arrangement.

18. A duplexer including the filter according to claim 16.

19. A duplexer including the filter according to claim 17.

20. An electronic communication device including at least one piezoelectric resonator according to claim 1.